CIVL 498C: WHOLE BUILDING LIFE CYCLE ASSESSMENT

April 6th,2011

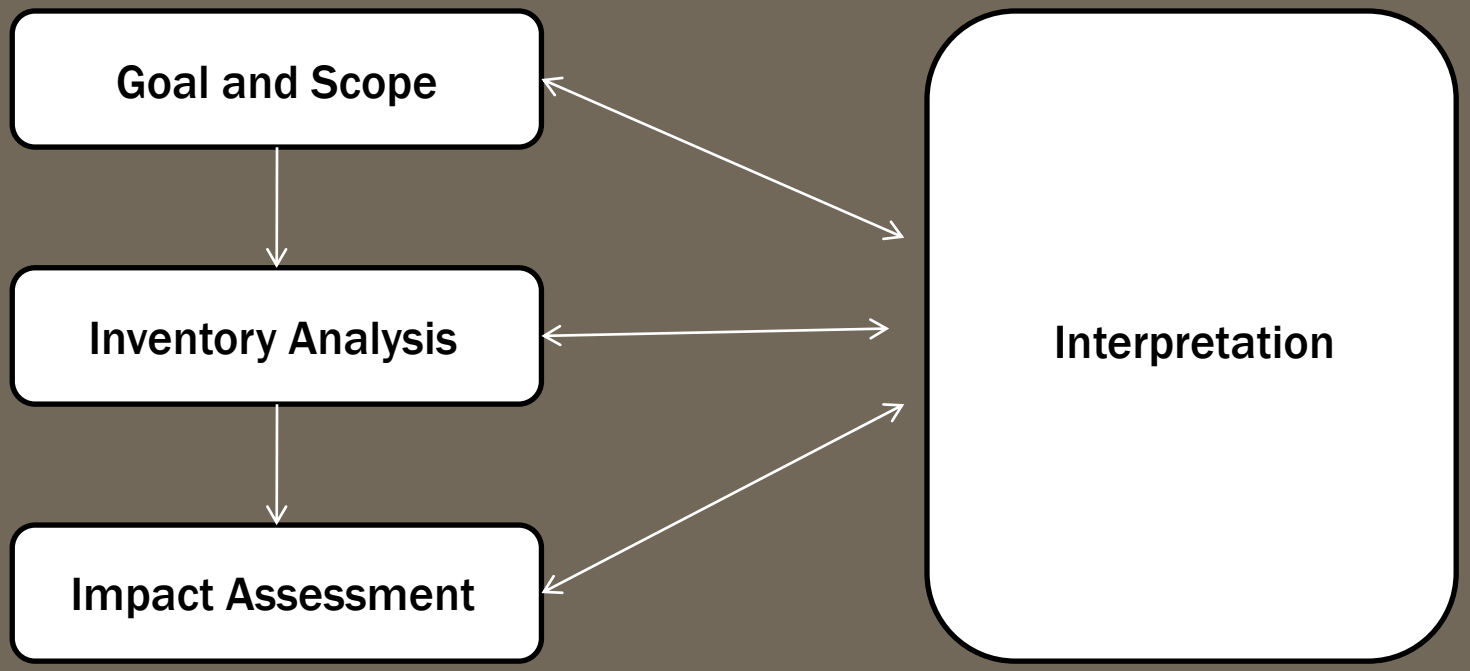
OVERVIEW

- Introduction
  - What is LCA?
  - How can it help?
  - Goal and Scope
- Tools and methodology
  - Software
- Results
  - Environmental impact potential
  - Sensitivity analysis
  - Uncertainties
- Conclusion
  - London 2012
  - Recommendations
  - Where do we go from here?

WHAT IS LCA?

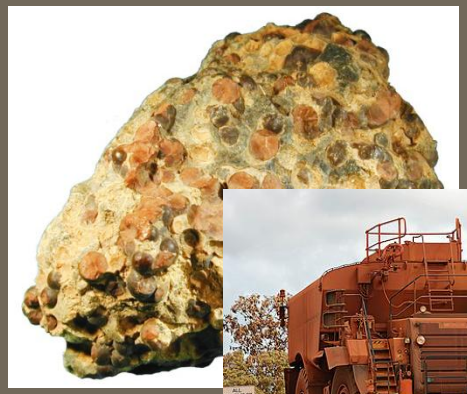
***L**ife **C**ycle **A**ssessment*

- A technique used to analyze and assess environmental impacts associated with all the stages of a product's life within a chosen system boundary



EVERY PRODUCTS LIFE CYCLE IS CREATED BY THE CONNECTIONS BETWEEN PROCESSES…

AND EACH PROCESS HAS INPUTS AND OUTPUTS TO WHICH IMPACT CAN BE ASSOCIATED

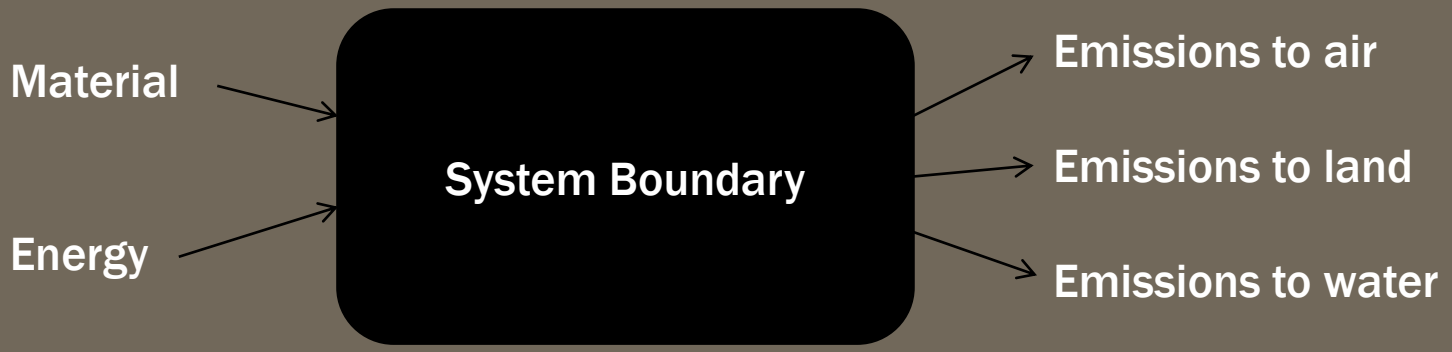


WHAT IS LCA?

- We can quantify and group these impacts into different environmental impact categories
- "Environmental accounting"
- Gaining attention as environmental stewardship increases
- ISO 14040, ISO 14044

GOAL

HOW CAN LCA HELP?

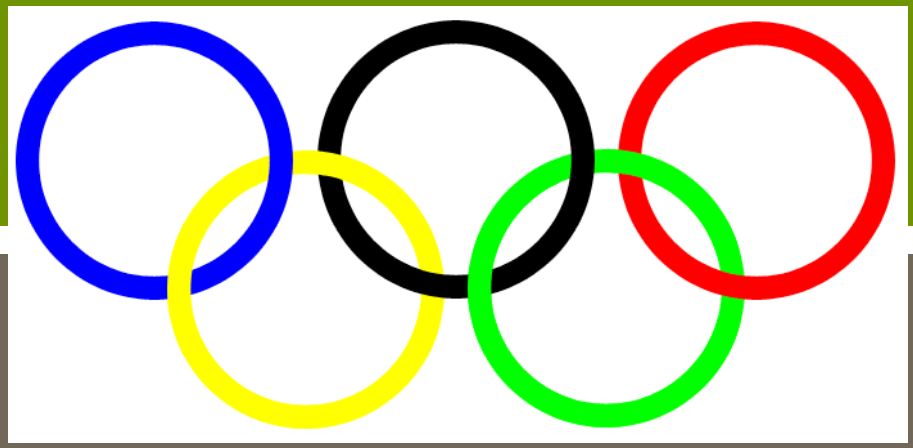


- Evaluate the potential impacts associated with these emissions
- Interpreting the results within the context and scope of the study
- Get LCA data to facilitate more LCA data

SCOPE

- 3 Olympic Venues
- Cradle to gate
- Structure and envelope

AUDIENCE



Everyone !!!

Developers
Engineers
Architects
Owners


DOUG MITCHELL THUNDERBIRD SPORTS CENTRE

BACKGROUND

Richmond Olympic Oval

- Officially opened on December 12, 2008
- Built to LEED Silver standards

- Maintained a 400m skating surface during the Olympics
- Hosted all speed skating events
- Now serves as a general athletics and convention center

BACKGROUND

Doug Mitchell Thunderbird Sports Center

- Opened on July 7, 2008
- Built to LEED Silver standards
- Renovation and Reconstruction of the Thunderbird Winter Sports Complex

- Hosted Ice and Sledge Hockey Events
- Home of the UBC Thunderbirds Hockey Teams

BACKGROUND

Thunderbird Winter Sports Center

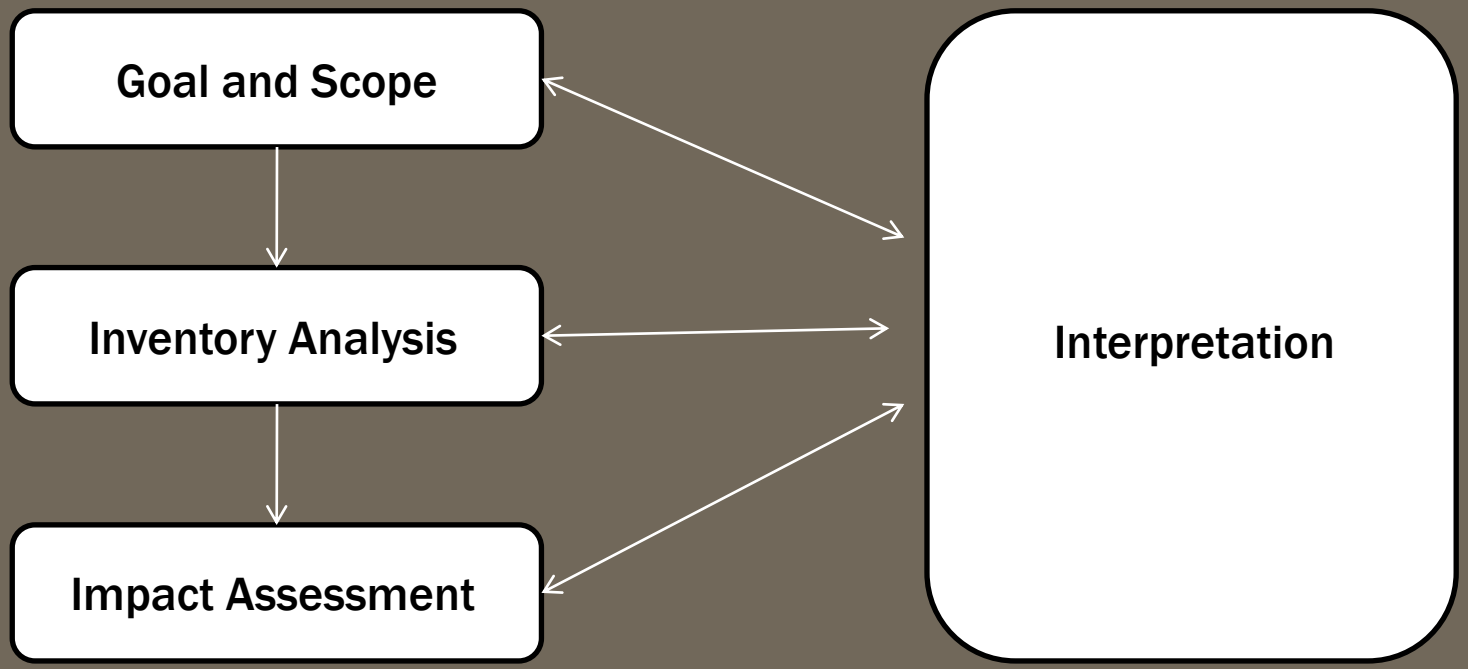
- Originally opened in 1963
- Expanded in 1968/1969
- 3 full-size rinks, curling arena and squash/handball courts

- Home of Canada's first national hockey team (1963)
- Father Bauer Arena was retained by the Doug Mitchell Center and used as a practice rink for the Olympics

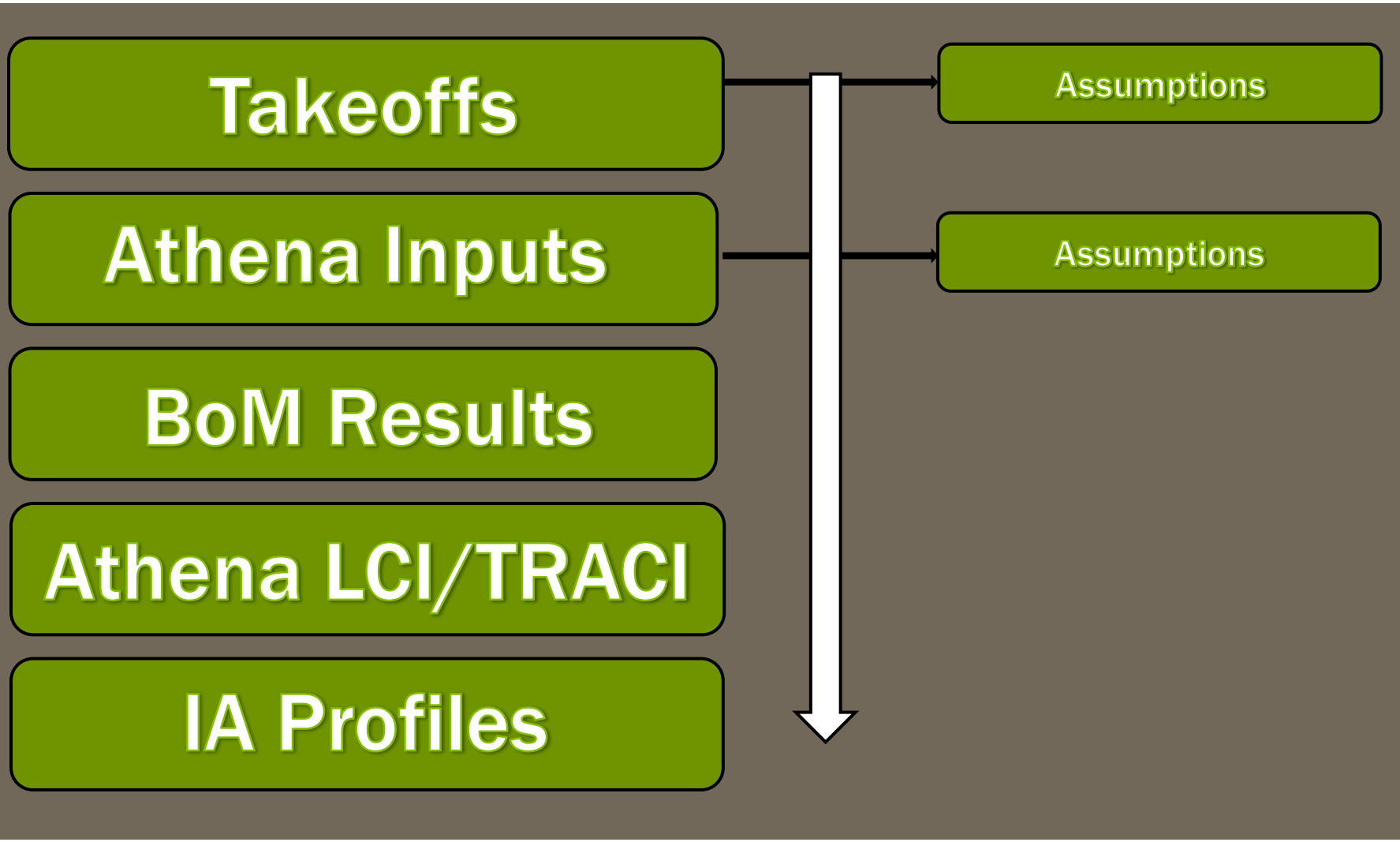
BACKGROUND

- The Father Bauer Arena is a portion of the current Doug Mitchell Thunderbird Sports Centre that remains from the original Thunderbird Arena construction.
- Life Cycle Impacts of Father Bauer Arena apportioned to LCA of Old Thunderbird as it was a part of the initial development.

METHODOLOGY



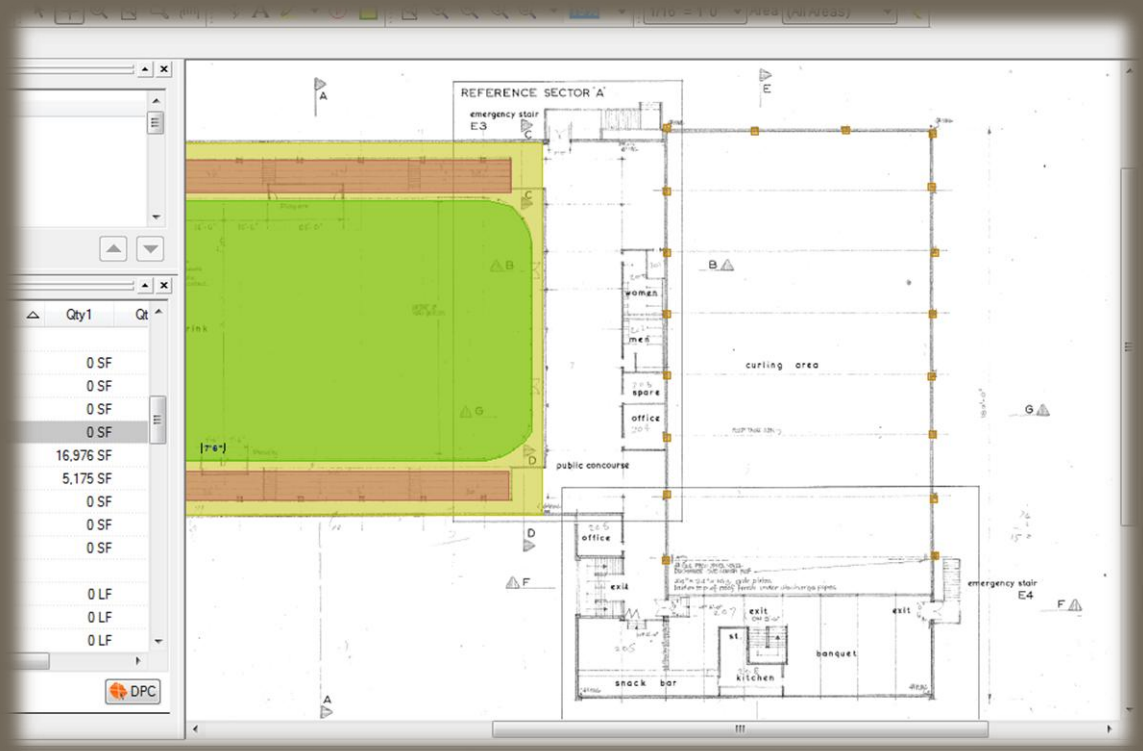
METHODOLOGY



METHODOLOGY
– TOOLS USED –

Takeoffs

Using On-Screen Takeoff

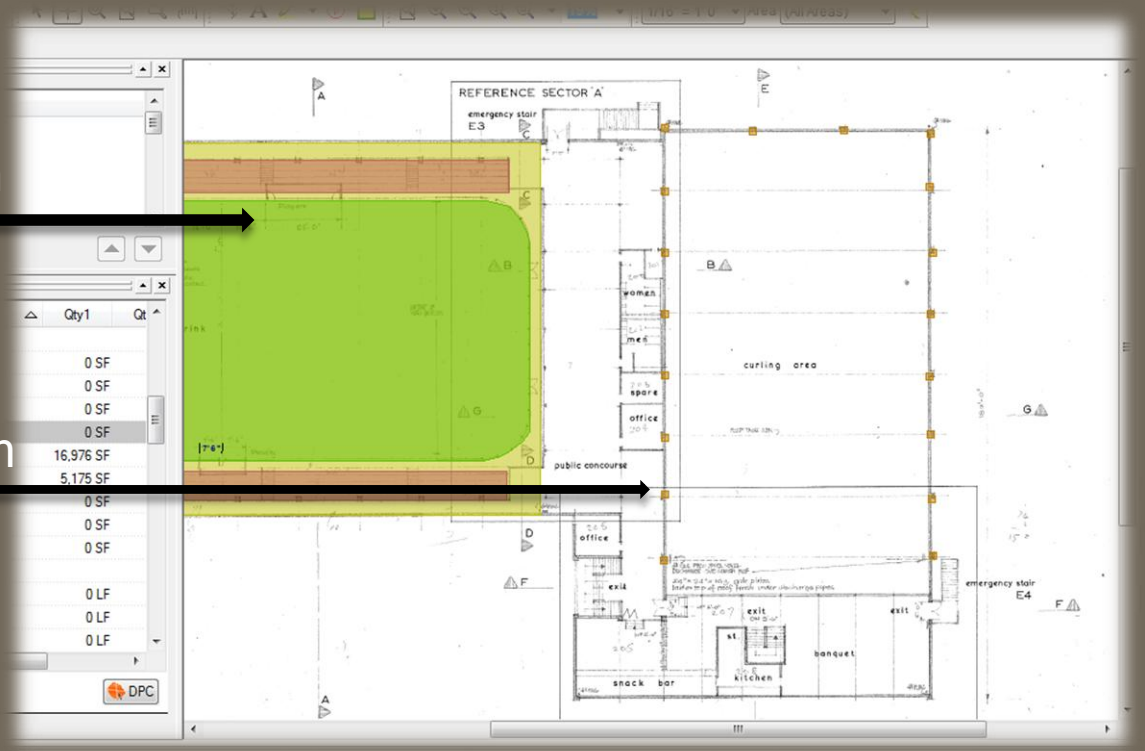


METHODOLOGY
– TOOLS USED –

Takeoff Examples

Area Condition

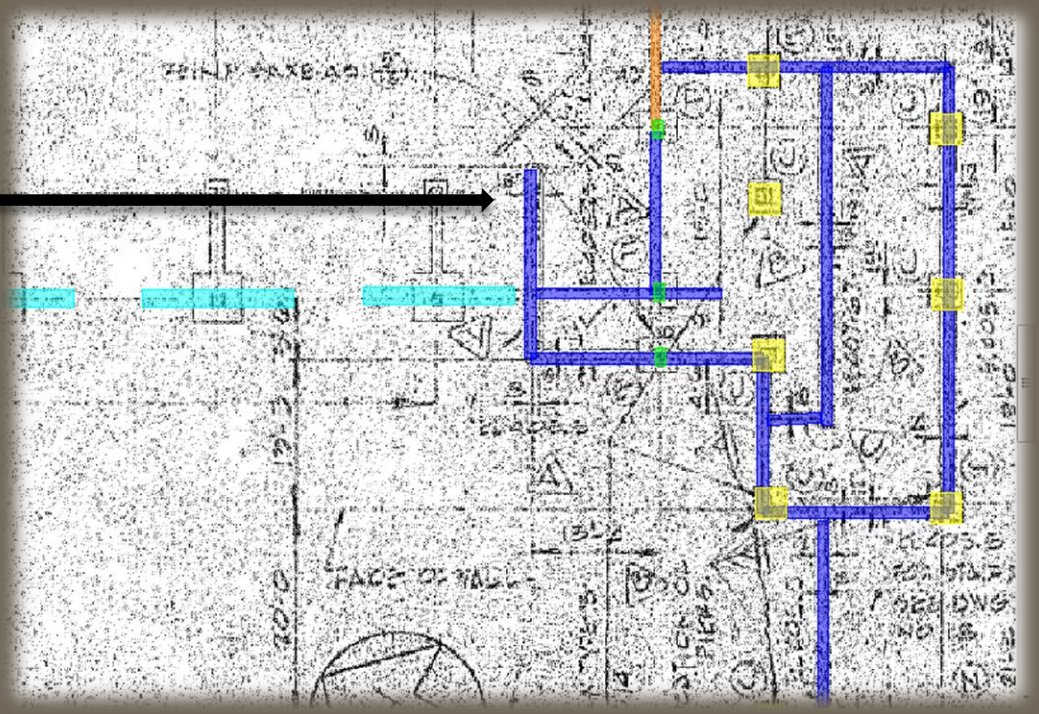
Count Condition



METHODOLOGY
– TOOLS USED –

Takeoff Examples

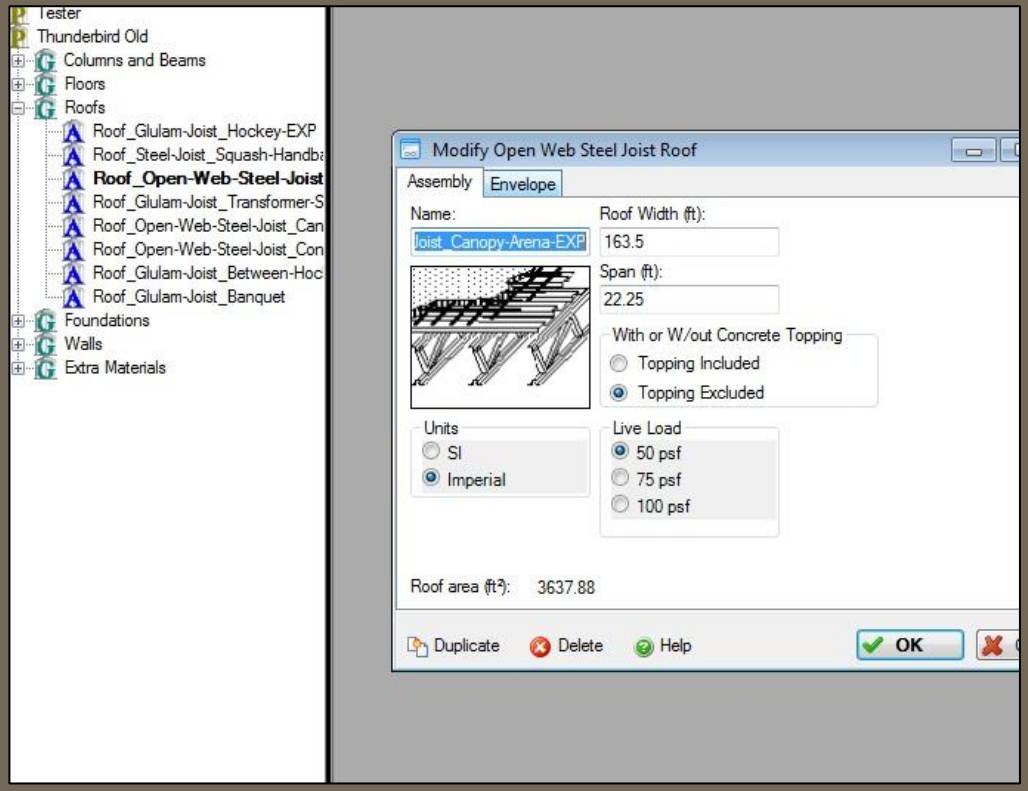
Linear Conditions



METHODOLOGY
– TOOLS USED –

Athena Inputs

Athena Impact Estimator 4.1

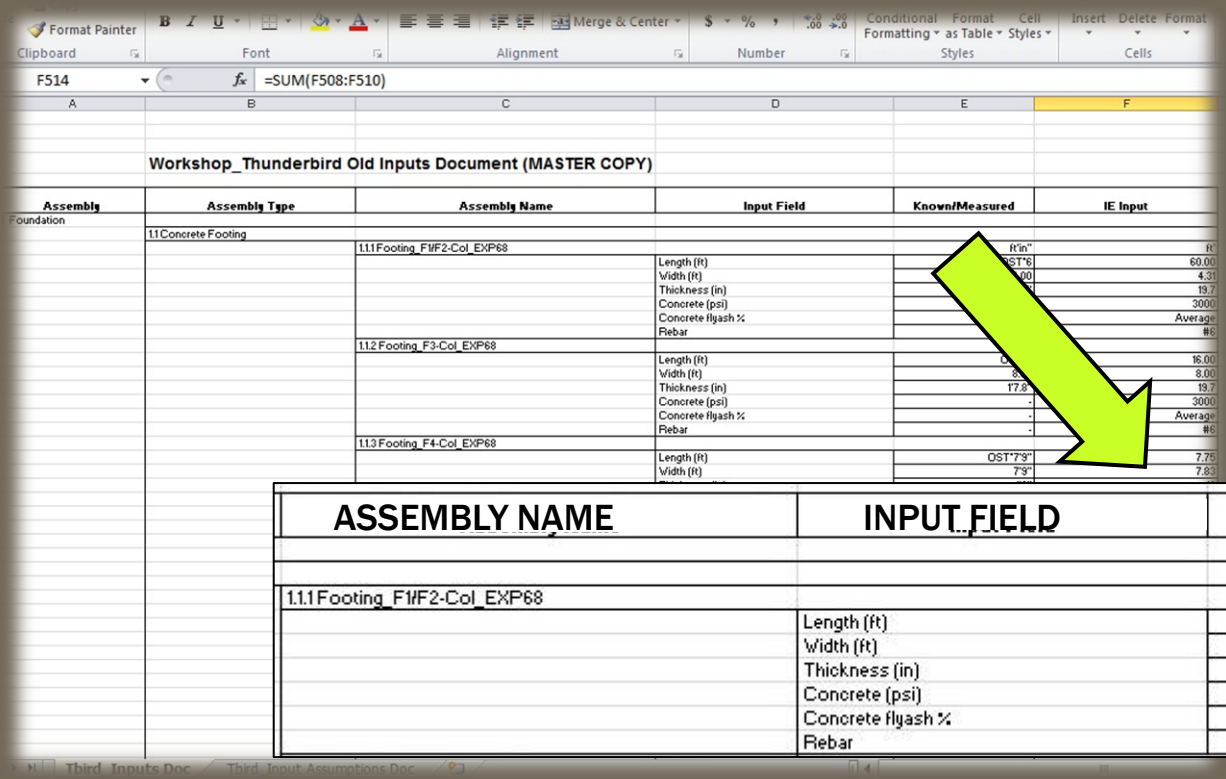


Inputs from Inputs Assumption Document

Findings entered into IE

Used to generate BoM

METHODOLOGY
– TRANSPARENCY–



F514 =SUM(F508:F510)

Workshop_Thunderbird Old Inputs Document (MASTER COPY)

Assembly	Assembly Type	Assembly Name	Input Field	Known/Measured	IE Input
Foundation					
	1.1 Concrete Footing				
		1.1.1 Footing_F1/F2-Col_EXP68		ft'in"	ft'
			Length (ft)	OST*6	60.00
			Width (ft)	.00	4.31
			Thickness (in)		19.7
			Concrete (psi)		3000
			Concrete flyash %		Average
			Rebar		#6
		1.1.2 Footing_F3-Col_EXP68			
			Length (ft)	C	16.00
			Width (ft)	8	8.00
			Thickness (in)	17.8	19.7
			Concrete (psi)	-	3000
			Concrete flyash %	-	Average
			Rebar	-	#6
		1.1.3 Footing_F4-Col_EXP68			
			Length (ft)	OST*7'9"	7.75
			Width (ft)	7'9"	7.83

ASSEMBLY NAME	INPUT FIELD	MEASURED	IE INPUT
1.1.1 Footing_F1/F2-Col_EXP68		ft'in"	ft'
	Length (ft)	OST*6	60.00
	Width (ft)	4.00	4.31
	Thickness (in)	1.95'	19.7
	Concrete (psi)	-	3000
	Concrete flyash %	-	Average
	Rebar	-	#6

- Helps with Impact Estimator Inputs
- Provides transparency for all assumptions used during the project

METHODOLOGY

Bill of Materials Output

Material	Quantity	Unit	Columns/ Beams	Floors	Roofing	Foundations	Walls
#15 Organic Felt	99836.10	m2			24959.025		
1/2" Moisture Resistant	1169.39	m2			1169.39		
1/2" Regular Gypsum	812.44	m2		812.44			
3 mil Polyethylene	224.38	m2					224.38
Aluminum	8.34	Tonnes					8.34
Ballast (aggregate stone)	6058570.25	kg		5739523.25	319047		
Batt. Fiberglass	449.55	m2 (25mm)					449.55
Blown Cellulose	11297.36	m2 (25mm)			11297.36		
Cedar Wood Shiplap Siding	1850.52	m2					1850.52
Cedar Wood Tongue and	69.03	m2					69.03
Commercial(26 ga.) Steel	1488.49	m2					1488.49
Concrete 20 MPa (flyash av)	3589.31	m3		1652.93		1930.71	5.67
Concrete 30 MPa (flyash av)	168.97	m3	163.32				5.65
Concrete Blocks	68977.12	Blocks					68977.12
EPDM membrane (black, 60	722.53	kg					722.53
Expanded Polystyrene	361.65	m2 (25mm)			355.14		6.51

METHODOLOGY

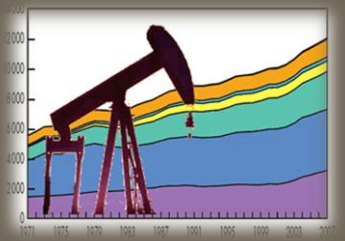
What do we do with all this information??

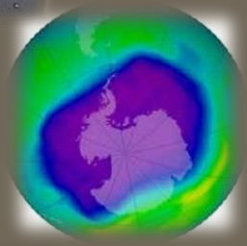
- Select impact categories
- Category indicators

METHODOLOGY

Selected Impact Categories include:

- Fossil Fuel Consumption
- Weighted Resource Depletion
- Smog Formation
- Global Warming Potential
- Ozone Layer Depletion
- Eutrophication Potential
- Human Health Respiratory Effects
- Acidification Potential





Source: http://www.epa.gov/nrmrl/std/sab/traci/

METHODOLOGY

- Fossil Fuel Consumption

Category Indicator: MJ

- All fossil fuel, direct and indirect, used to transform or transport raw materials into products and buildings
- Characterized by Athena
- Expressed in fossil fuel consumption

METHODOLOGY

- Weighted Resource Use

Category Indicator: kg of Resources

- The ecological weight of resources used on site

- Characterized by:
  - Land use and areas impacted
  - Duration of impacts
  - Ecological significance

METHODOLOGY

- Smog Formation

Category Indicator: kg NO_x equivalent

- Ground level ozone created through reaction of VOCs and NO_x in the presence of sunlight

- Effects human health
- Can reduce crop yield due to lack of sufficient photosynthesis
- Smog is worse in densely populated regions, especially in valley areas = VANCOUVER

http://www.cbc.ca/news/background/environment/smog.html

METHODOLOGY

- Global Warming Potential

Category Indicator: kg CO_2 equivalent

- Capacity to absorb infrared radiation, which heats the atmosphere
- Characterized by Intergovernmental Panel on Climate Change (IPCC)
- 11 of the past 12 years are among the warmest since 1850
- Arctic may have its first ice-free summer by 2040

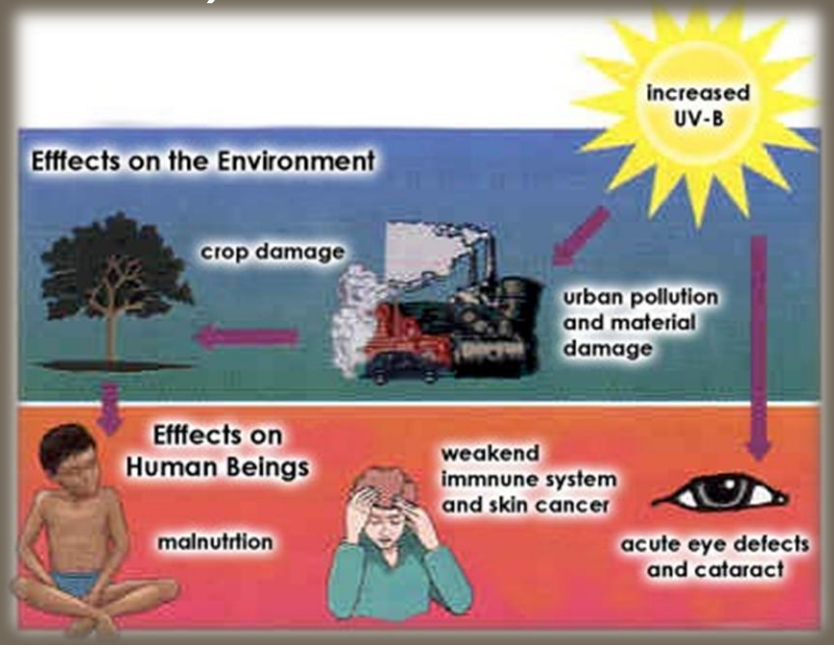
http://news.nationalgeographic.com/news

METHODOLOGY

- Ozone Layer Depletion

Category Indicator: kg CFC-11 equivalent

- **Destruction of the upper atmospheric ozone column due to the emissions of substances (HFCs and Halons) relative to CFC-11**
- Characterized by World Meteorological Organization (WMO)
- Increased UVB reaching the earth



METHODOLOGY

- Eutrophication Potential

Category Indicator: kg Nitrogen equivalent

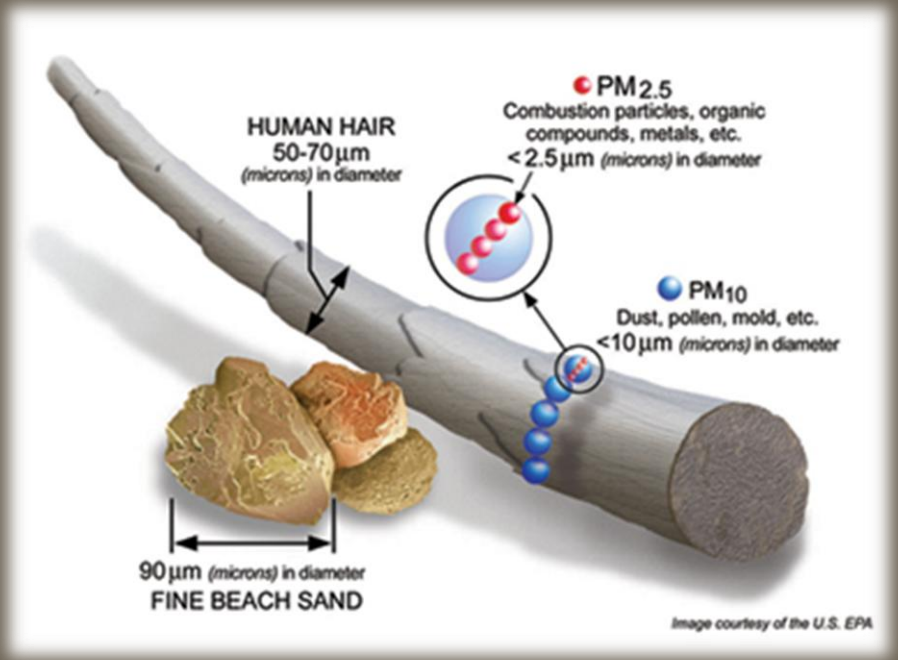
- Aquatic Eutrophication occurs when bodies of water are enriched with nutrients from waste water discharge resulting in algae over growth
- Characterized by US EPA
- Kills fish and shellfish
- Toxicity to human, marine mammals, livestock
- Effects recreation, industry, and ecosystem

METHODOLOGY

- Human Health Respiratory Effects

Category Indicator: kg PM2.5 equivalent

- Exposure to airborne particulate matter less than 2.5 µm in size
- Characterized by USA EPA
- Effects human health
  - Coughing, wheezing
  - Worsens asthma, heart disease, pneumonia



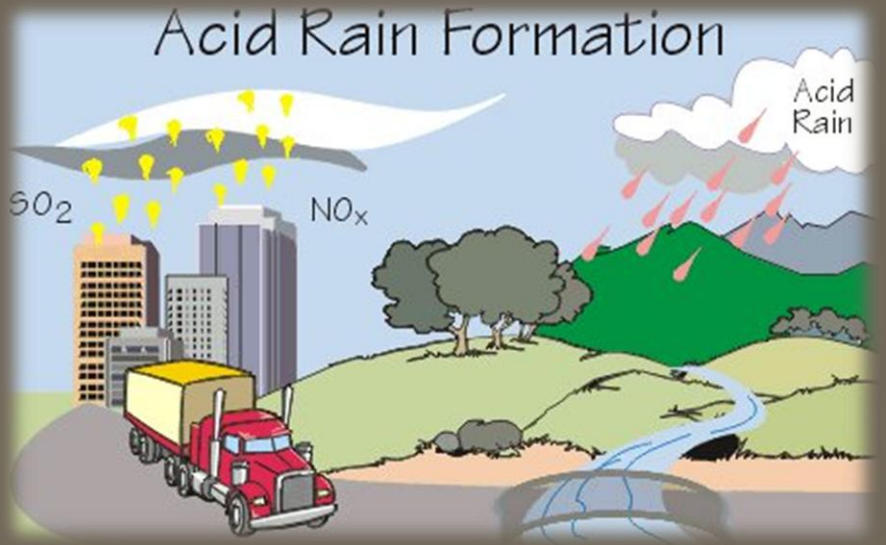
http://www.euro.who.int/__data/assets/pdf_file/0006/78657/E88189.pdf

METHODOLOGY

- Acidification Potential

Category Indicator: moles of H+ equivalent

- Capacity to form H+ ions from SO_2 and NO_x, increasing acidity of soil and water systems
- Characterized by US EPA
- Ecosystem changes
- Plant and animal mortality



METHODOLOGY

- Interpreting Results
  - Grouping Impacts
    - Local, Regional, Global
  - Normalizing Impacts
    - Benchmark comparisons

  - Completeness Check – Sensitivity Analysis
    - How sensitive/responsive certain categories are to changes in the model
    - What contribute most to the system (extraction, manufacturing, end of life)

Study Results

Building Characteristics

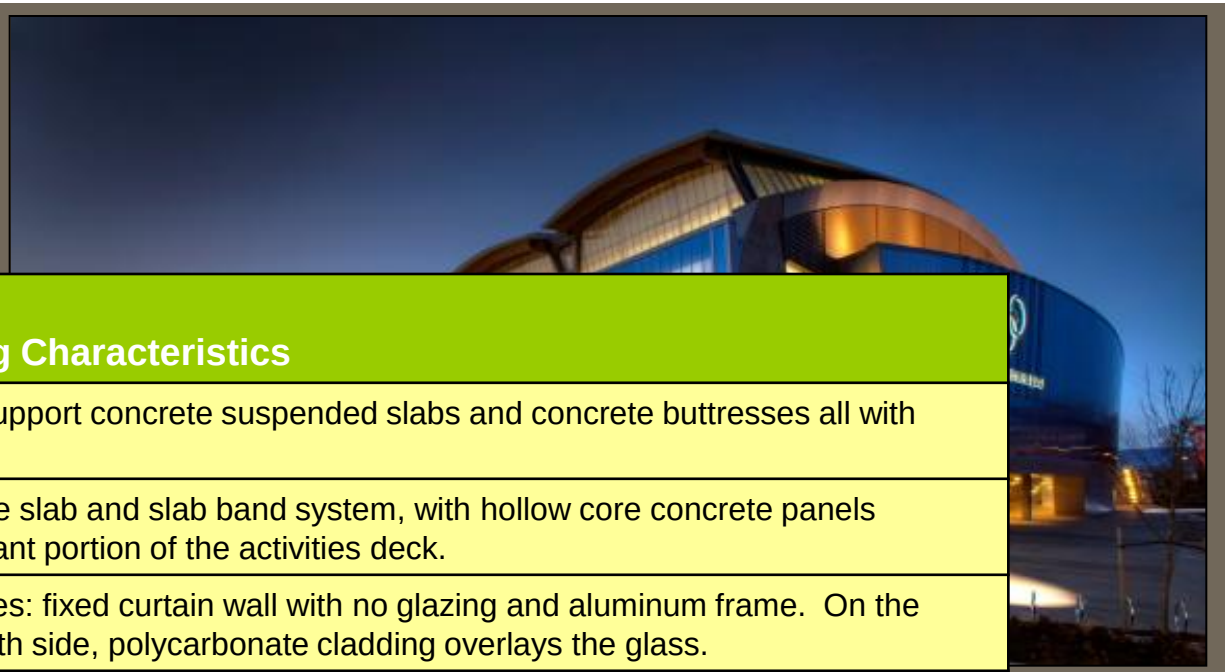
BUILDING CHARACTERISTICS
- Thunderbird Old -

Building System	Specific Building Characteristics
Structure	Concrete and steel columns supporting concrete suspended slabs
Floors	Ground Floor: Concrete slab on grade; First Floor: Suspended slab
Exterior Walls	8” Concrete block with several smaller sections of cast-in-place walls
Interior Walls	8” and 6” Concrete block construction with some wood stud partitions
Windows	All windows assumed to be standard glazing
Roof	Built-up roofs, Glulam and steel trusses

BUILDING CHARACTERISTICS
- Thunderbird New -

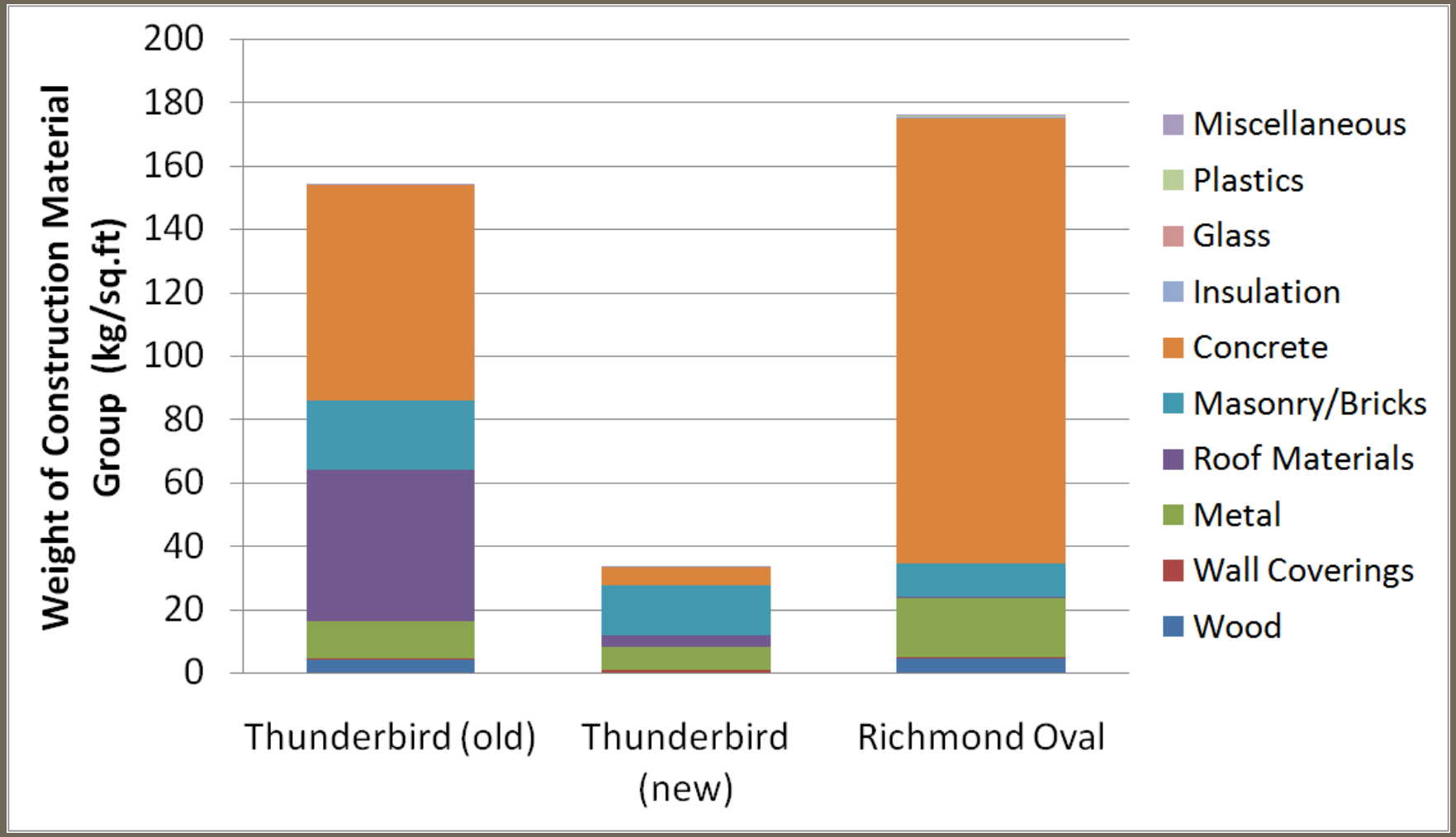
Building System	Specific Building Characteristics
Structure	Reinforced Concrete Frame, Concrete Block
Floors	Foundation: Concrete Slab on grade; floors are precast concrete double T
Exterior Walls	Foundation: Cast-in-place walls; Ground and the rest of the floors: concrete tilt-up and block, and wood stud
Interior Walls	Foundation: Cast-in-place walls; Ground and First Floors: wood stud with plywood sheating
Windows	All windows operable with aluminum frame and standard glazing
Roof	Concrete Precast Double T

BUILDING CHARACTERISTICS
- Richmond Oval -



Building System	Specific Building Characteristics
Structure	Concrete columns support concrete suspended slabs and concrete buttresses all with steel reinforcement
Floors	Floors are a concrete slab and slab band system, with hollow core concrete panels supporting a significant portion of the activities deck.
Exterior Walls	North and South sides: fixed curtain wall with no glazing and aluminum frame. On the third floor of the South side, polycarbonate cladding overlays the glass.
Interior Walls	Mainly steel stud walls with various amounts and types of gypsum board. Also concrete block walls with no envelope material and concrete cast-in-place walls.
Windows	Interior doors are either solid wood or hollow metal. Exterior doors are either hollow metal or sliding glass.
Roof	Concrete Precast Double TComposite beams composed of Glulam and structural steel support the main span of the roof, WoodWave engineered structural panels composed mainly of softwood lumber span between the composite beams and are filled with fibrous mineral wool insulation.

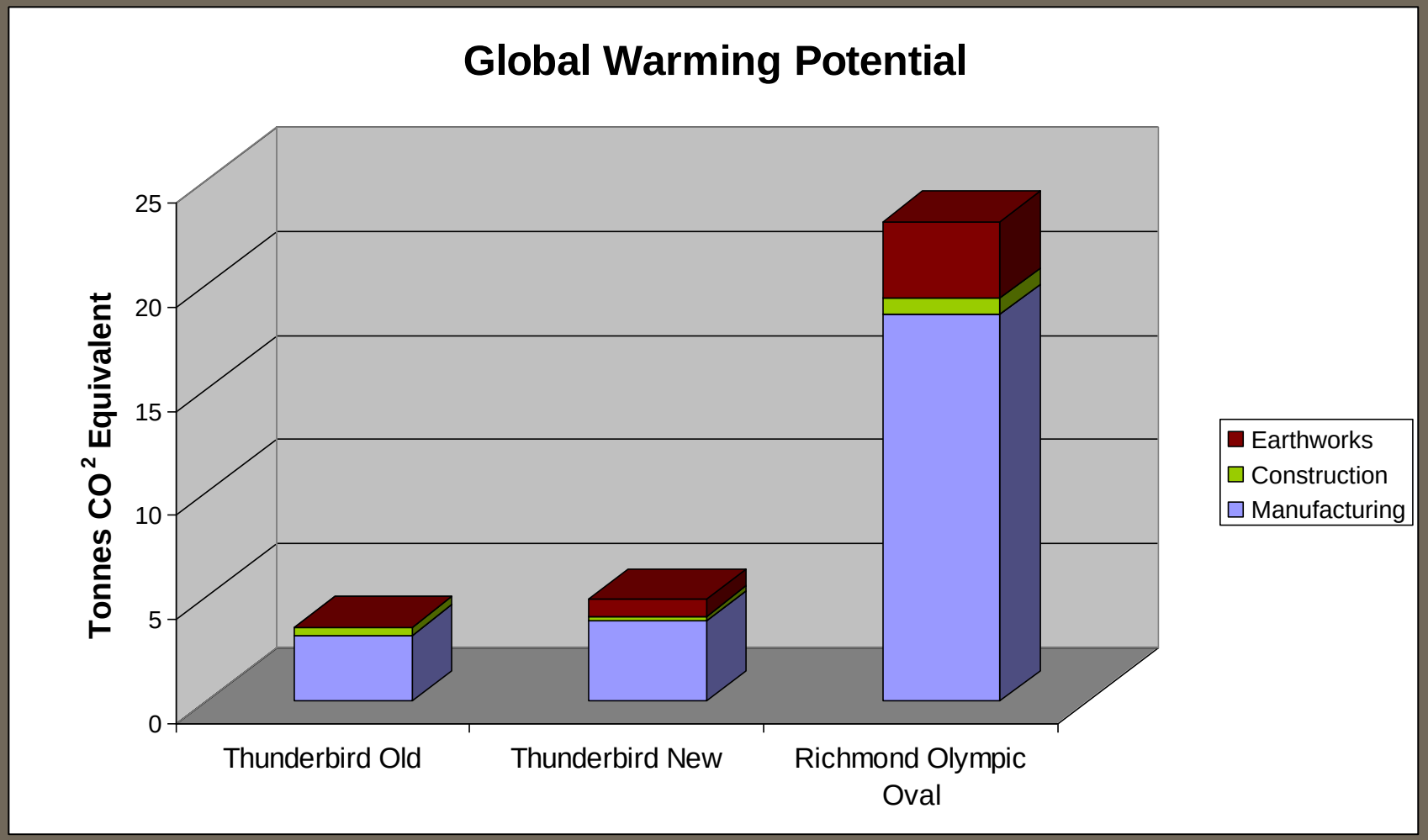
BUILDING CHARACTERISTICS
- Bill of Materials -



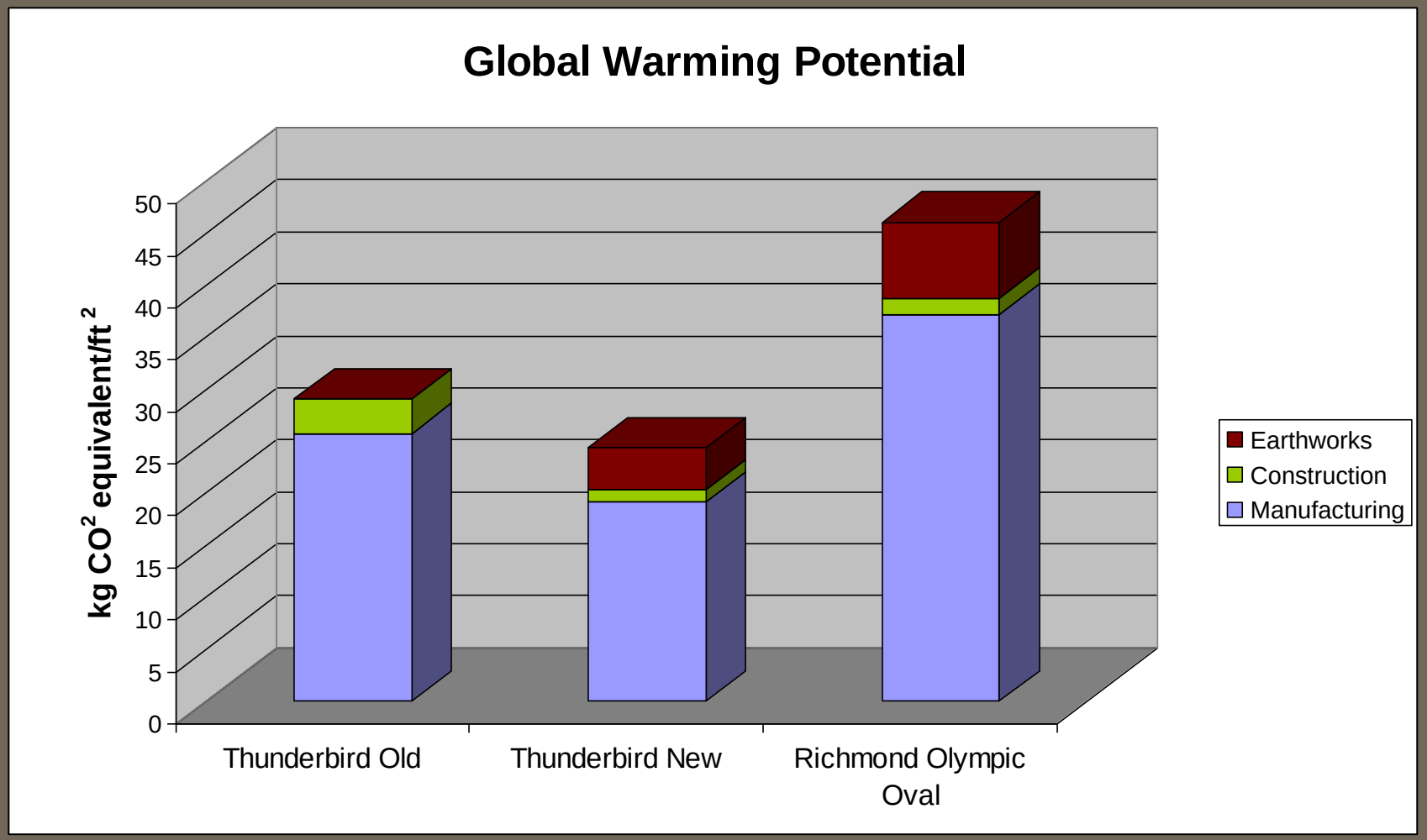
Study Results

Impact Categories

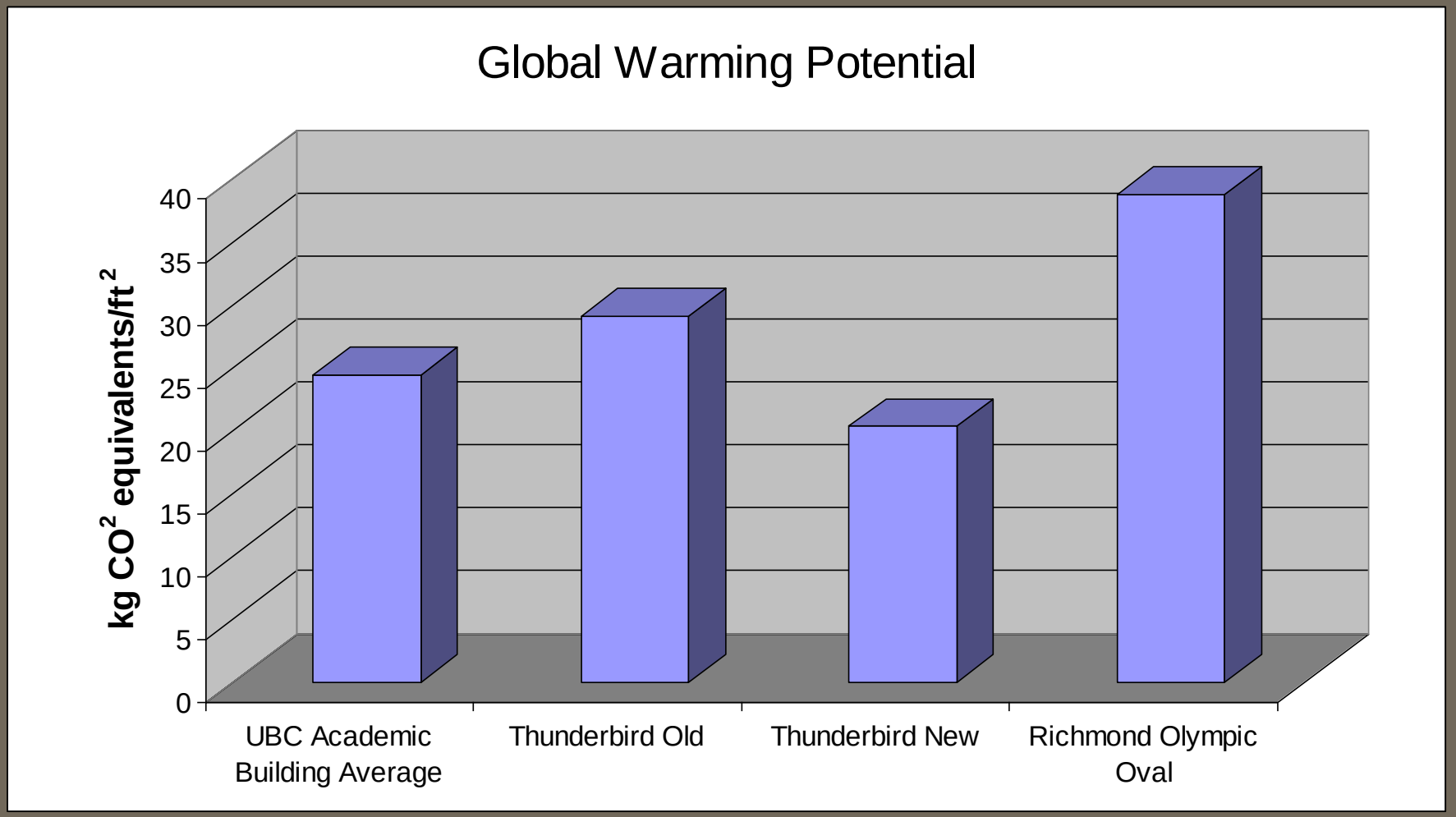
IMPACT ASSESSMENT
- Global Warming Potential per Building -



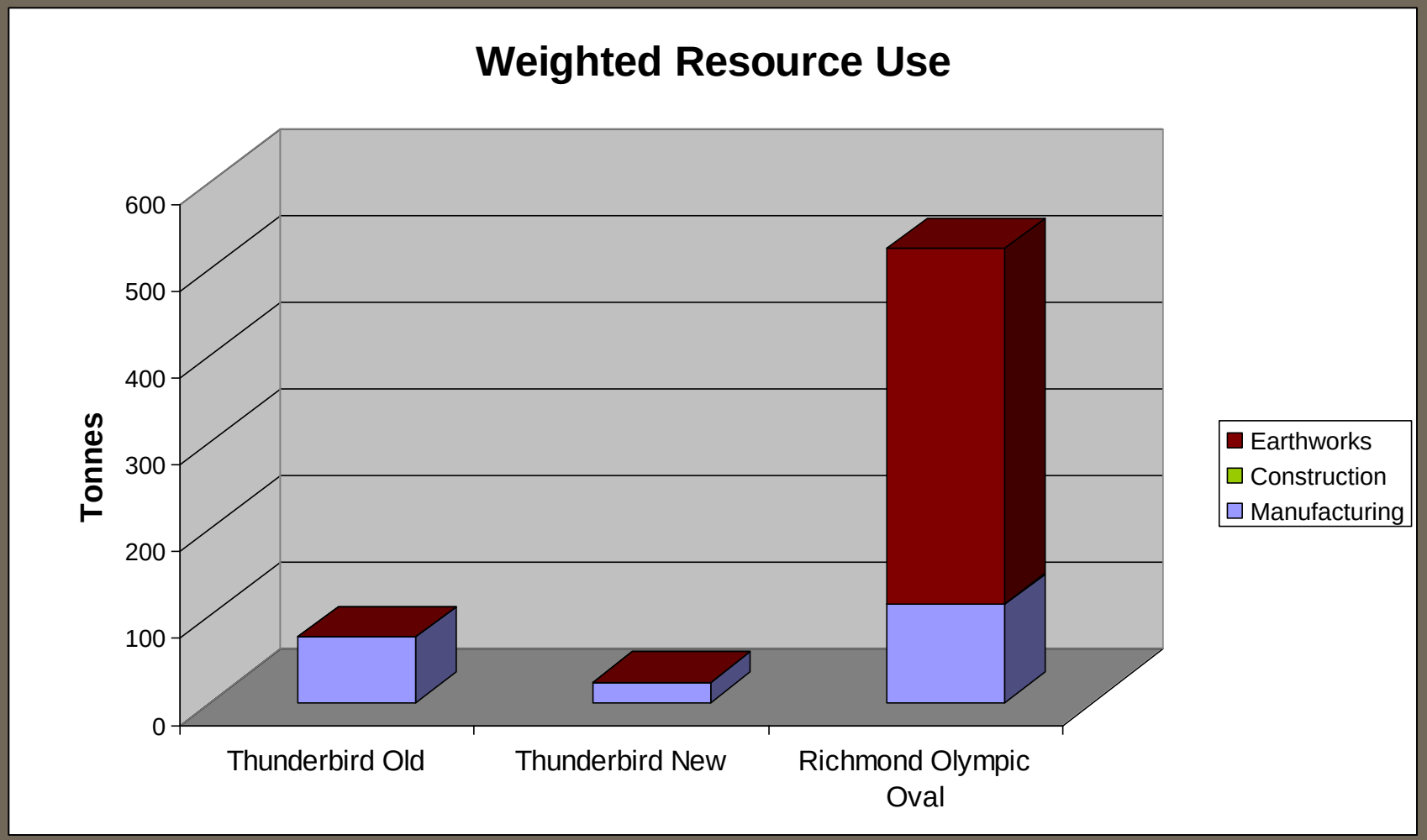
IMPACT ASSESSMENT
- Global Warming Potential per Sq.Ft. -



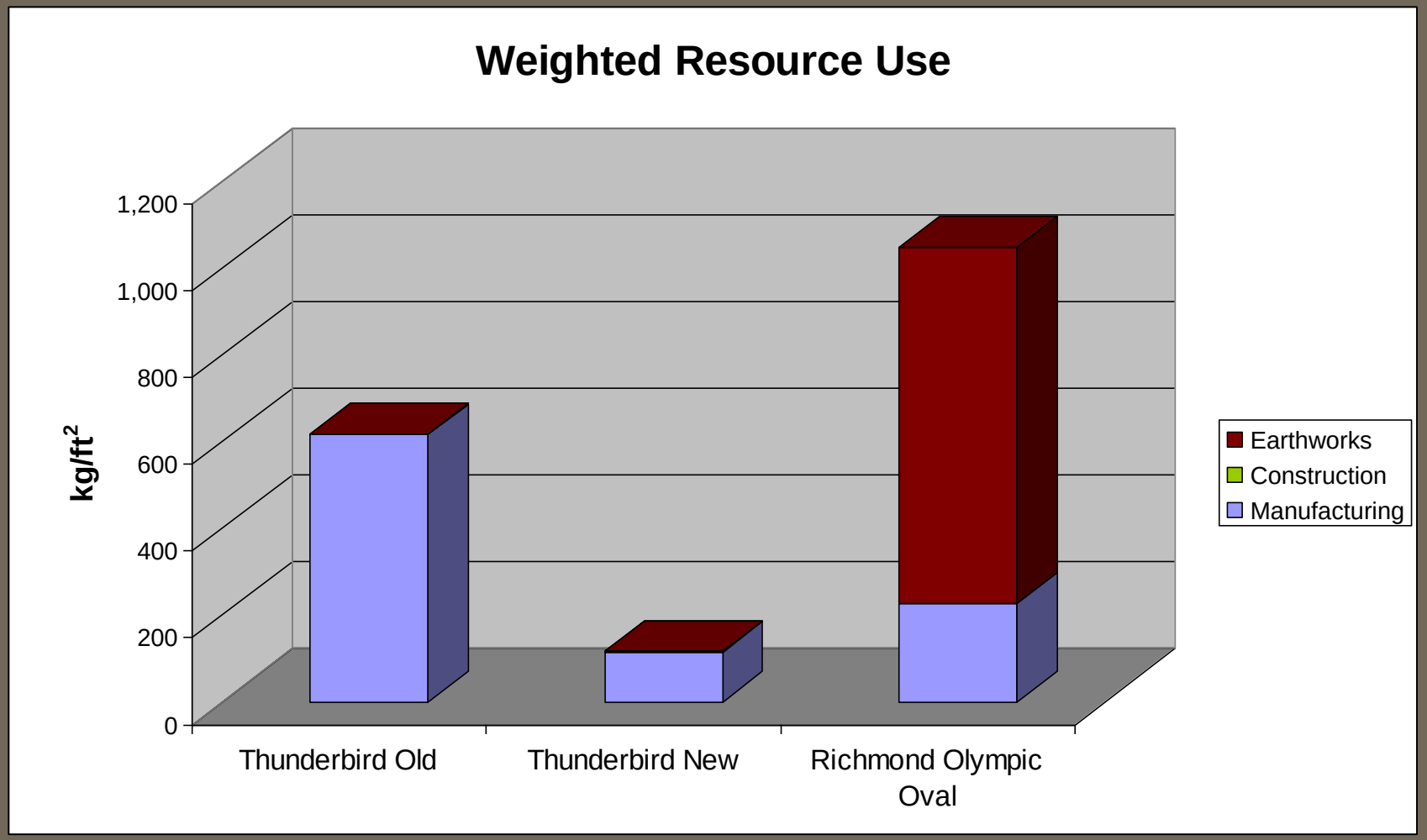
IMPACT ASSESSMENT
- UBC Average Comparison -



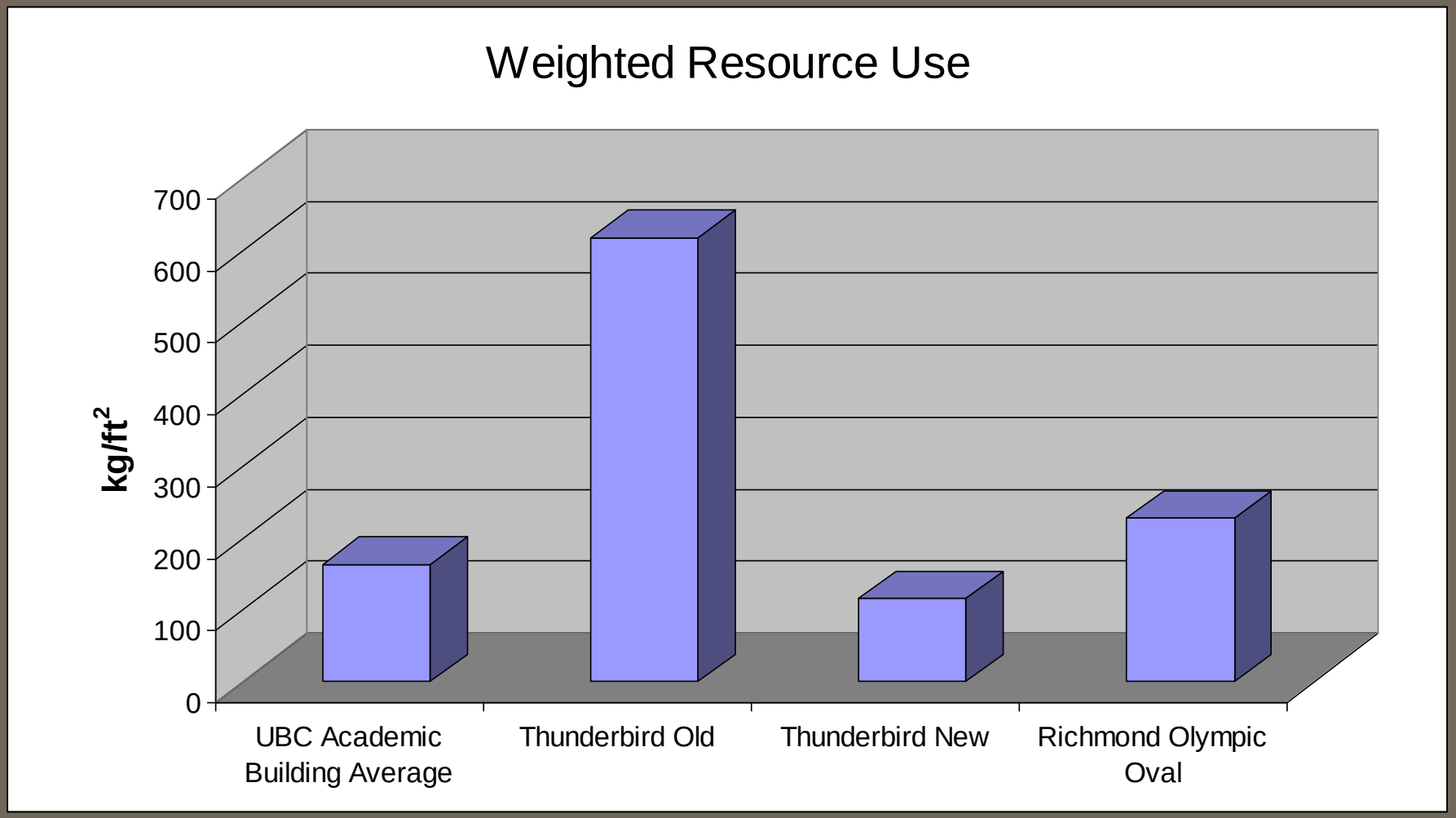
IMPACT ASSESSMENT
- Weighted Resource Use per Building -



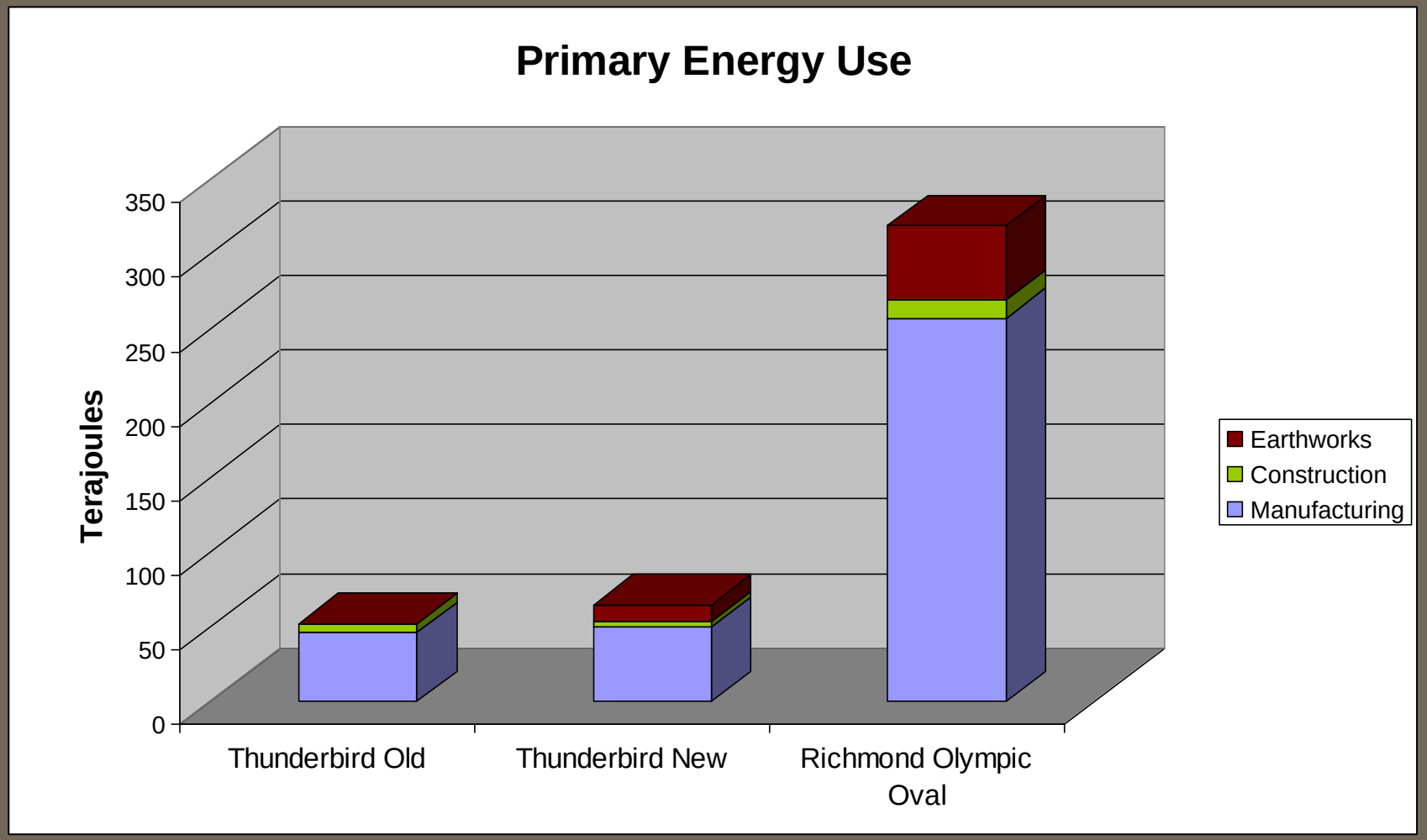
IMPACT ASSESSMENT
- Weighted Resource Use per Sq.Ft. -



IMPACT ASSESSMENT
- UBC Average Comparison -



IMPACT ASSESSMENT
- Fossil Fuel Consumption per Building -



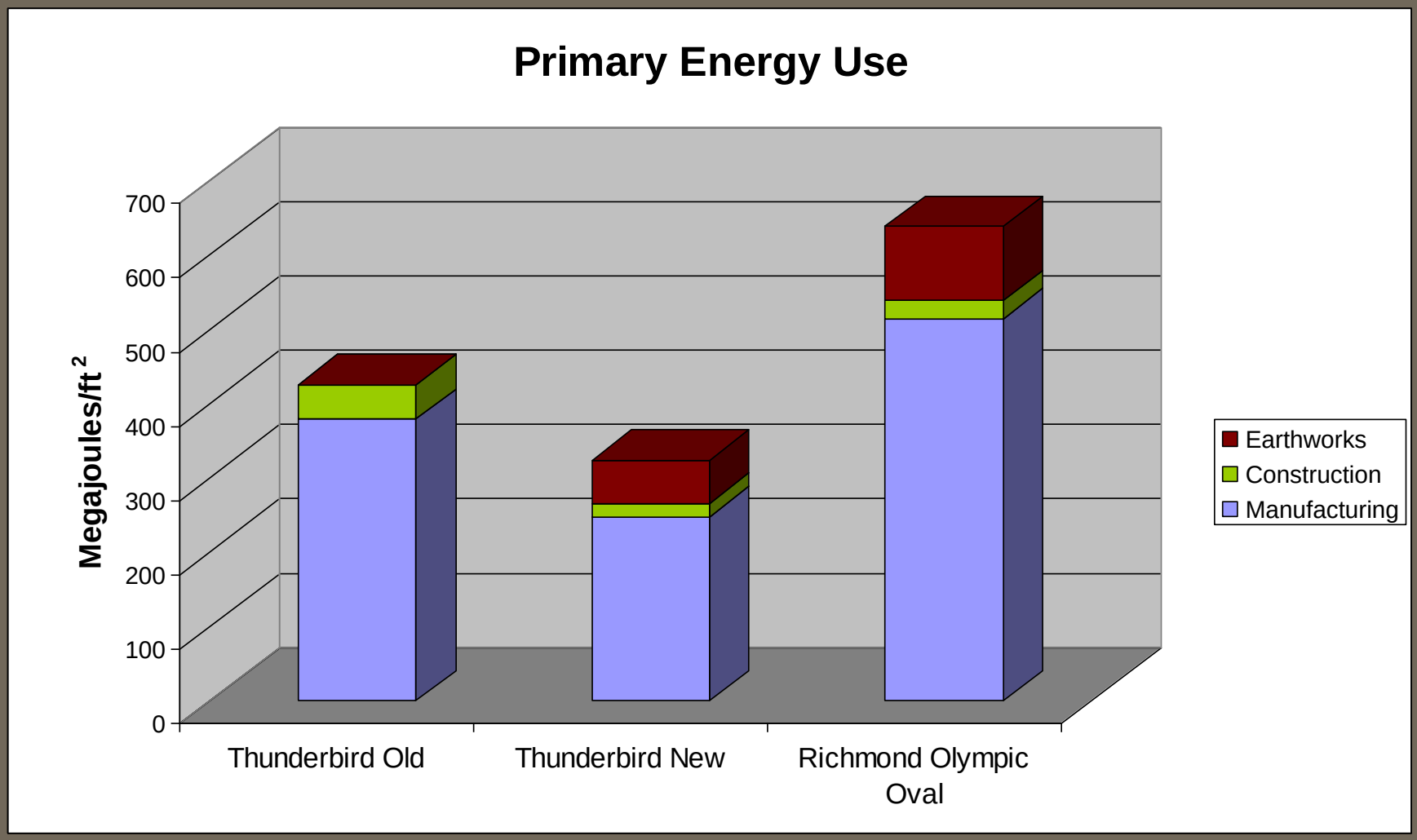
METHODOLOGY

- Where do we go from here??
  - Normalization
    - Benchmark against average

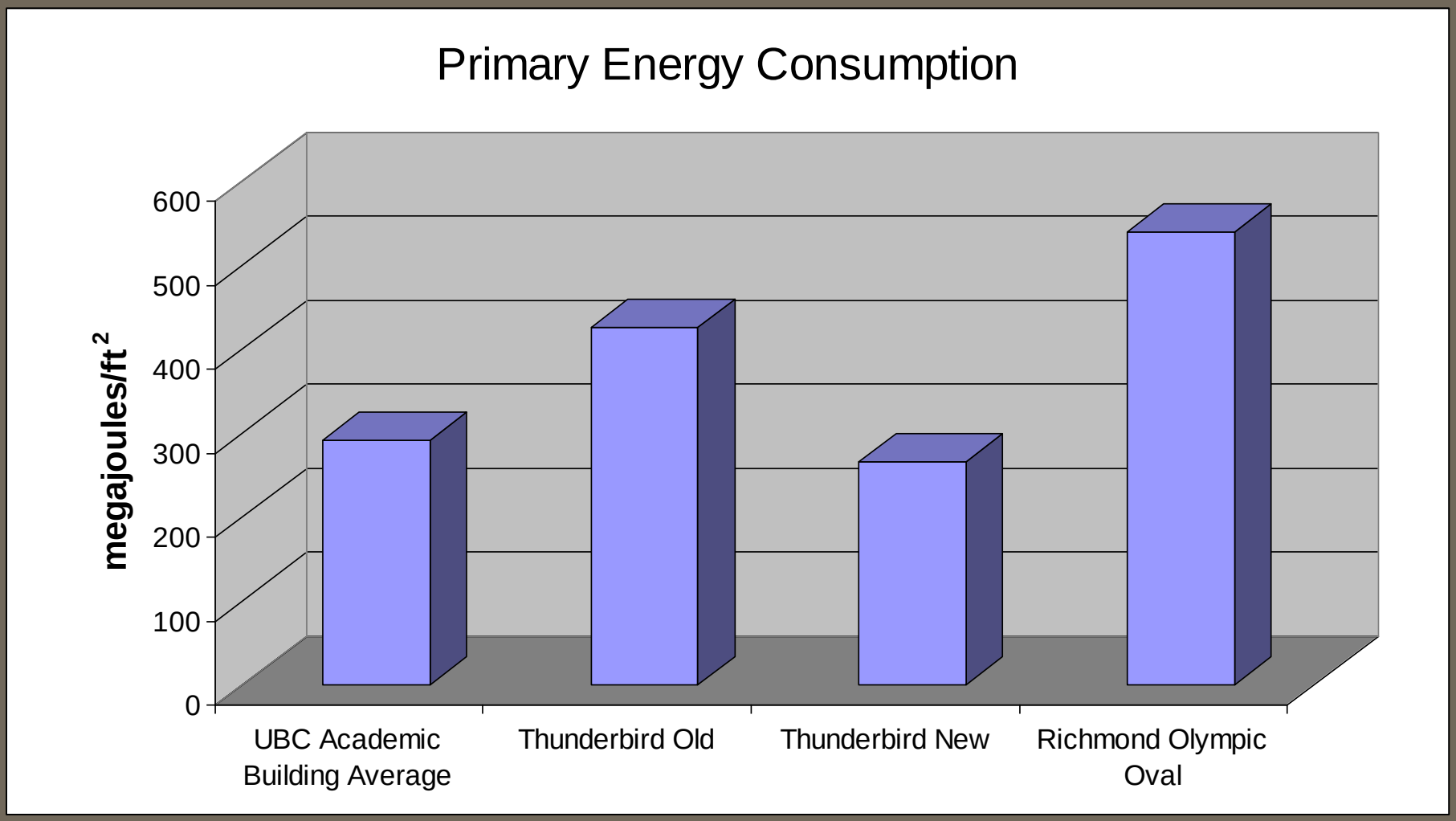
Fossil Fuel Consumption Thunderbird Arena (New) = 582 Houses Annual Energy Use

http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrs2/res_ca_1_e_4.cfm?attr=0

IMPACT ASSESSMENT
- Fossil Fuel Consumption per Sq.Ft. -



IMPACT ASSESSMENT
- UBC Average Comparison -

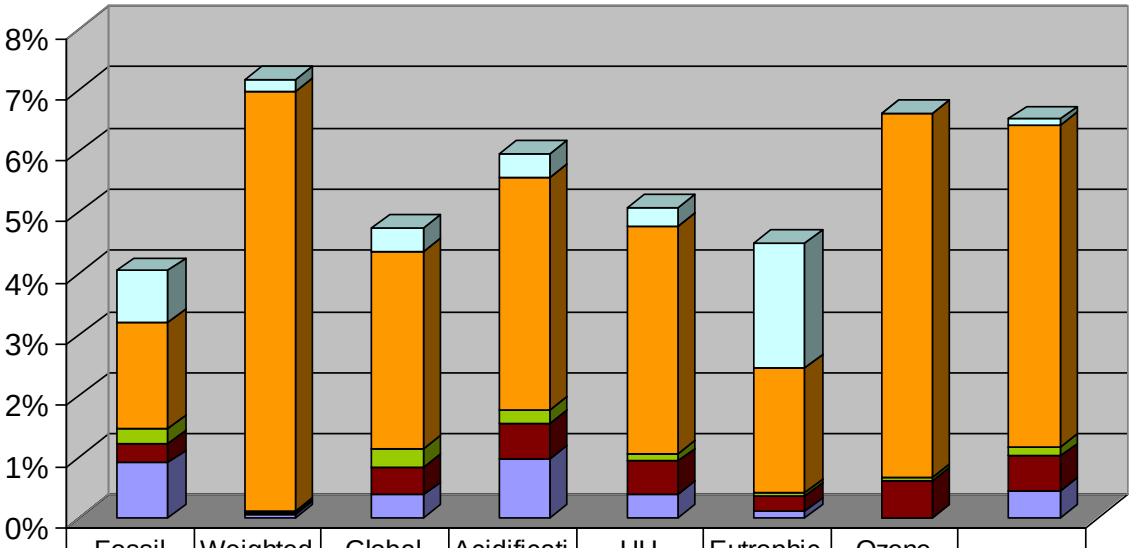


Study Results

Sensitivity Analysis

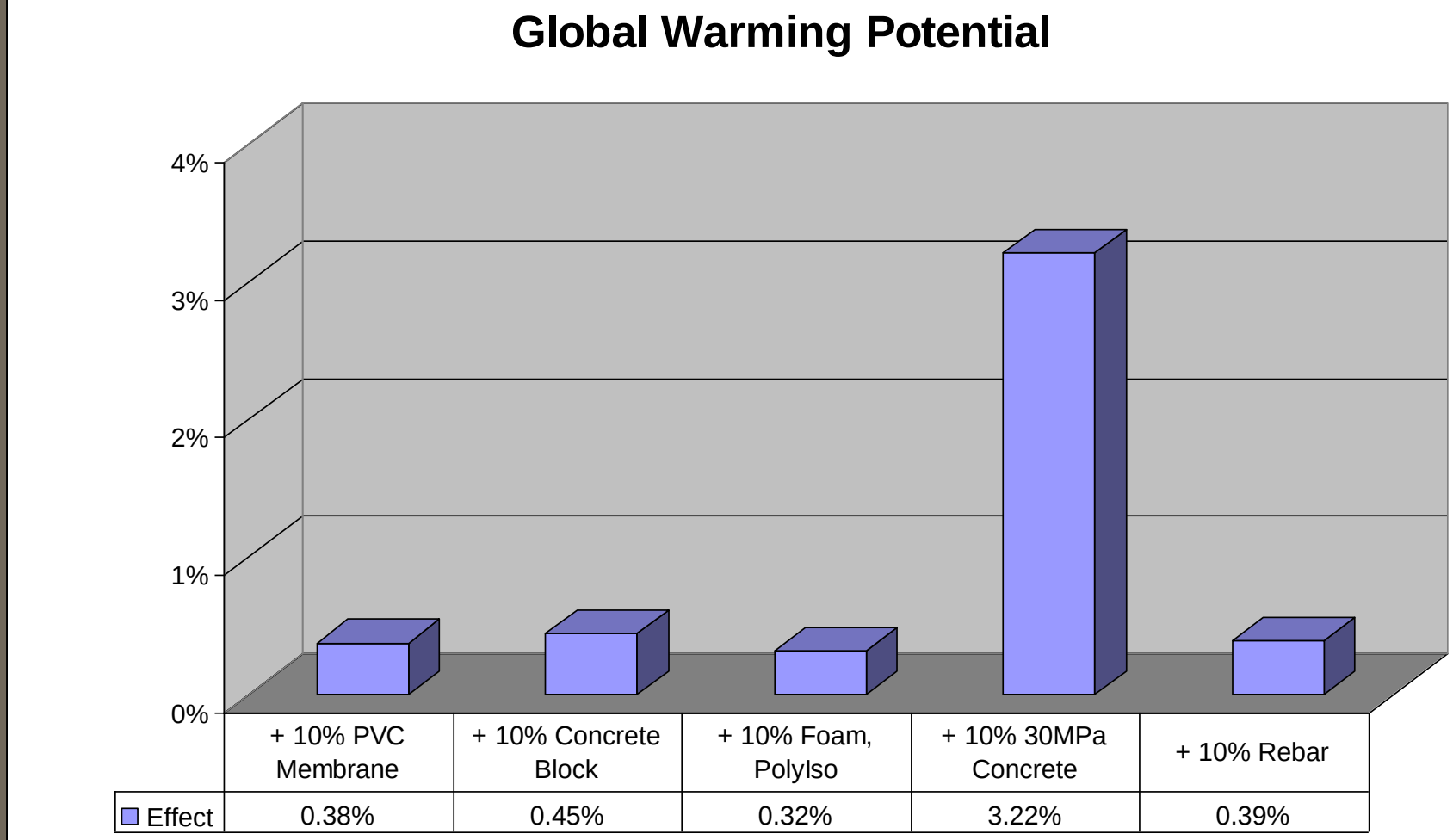
SENSITIVITY ANALYSIS

Sensitivity Analysis of the Thunderbird Arena (New)

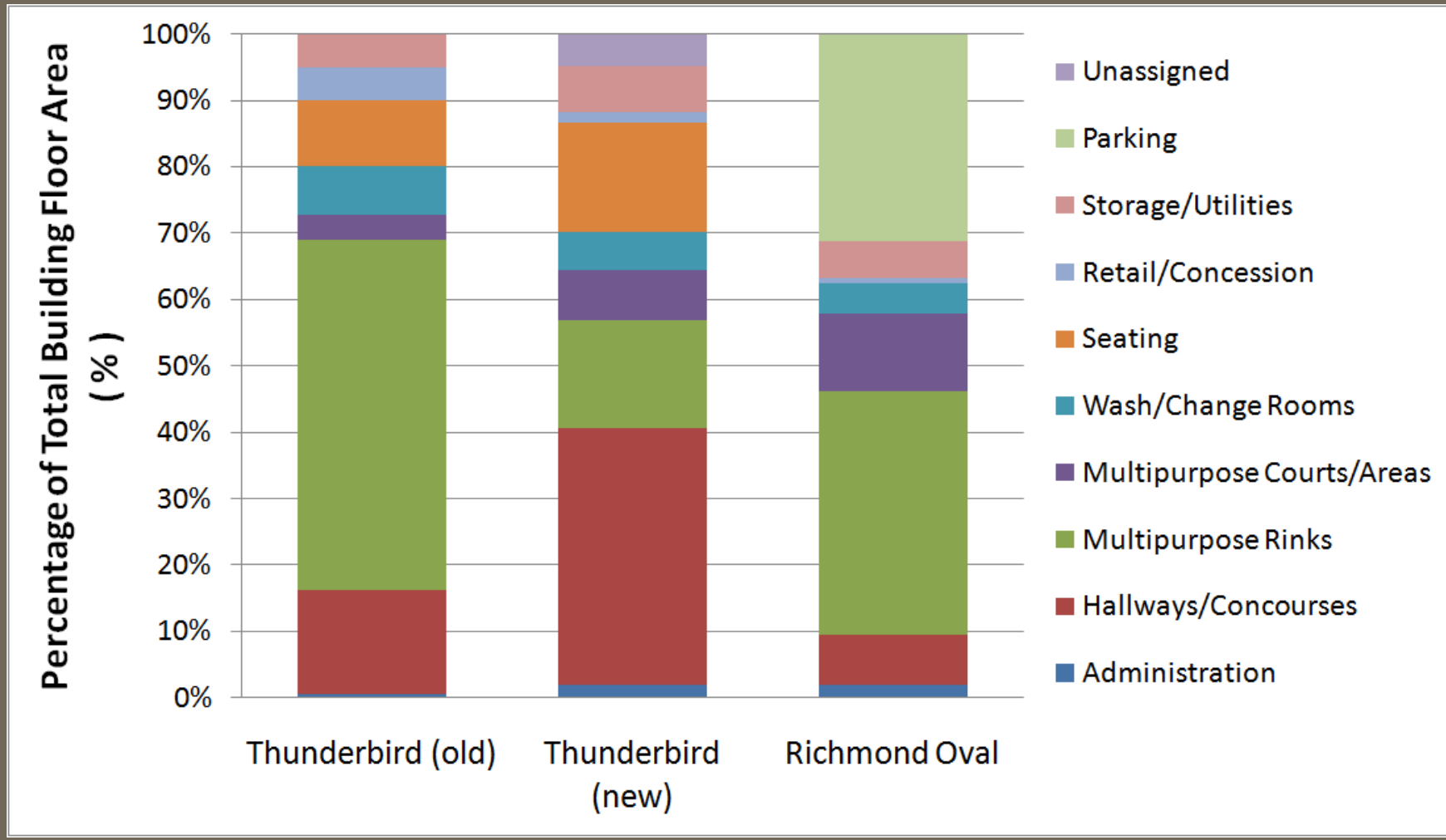


	Fossil Fuel Consump	Weighted Resource Use	Global Warming Potential	Acidification Potential	HH Respiratory Effects	Eutrophication Potential	Ozone Depletion Potential	Smog Potential
+ 10% Rebar	0.84%	0.18%	0.39%	0.39%	0.30%	2.02%	0.00%	0.10%
+ 10% 30MPa Concrete	1.73%	6.87%	3.22%	3.81%	3.72%	2.06%	5.94%	5.27%
+ 10% Foam, Polylso	0.24%	0.02%	0.32%	0.22%	0.12%	0.05%	0.04%	0.14%
+ 10% Concrete Block	0.33%	0.03%	0.45%	0.57%	0.54%	0.23%	0.62%	0.58%
+ 10% PVC Membrane	0.90%	0.07%	0.38%	0.97%	0.39%	0.13%	0.00%	0.44%

SENSITIVITY ANALYSIS

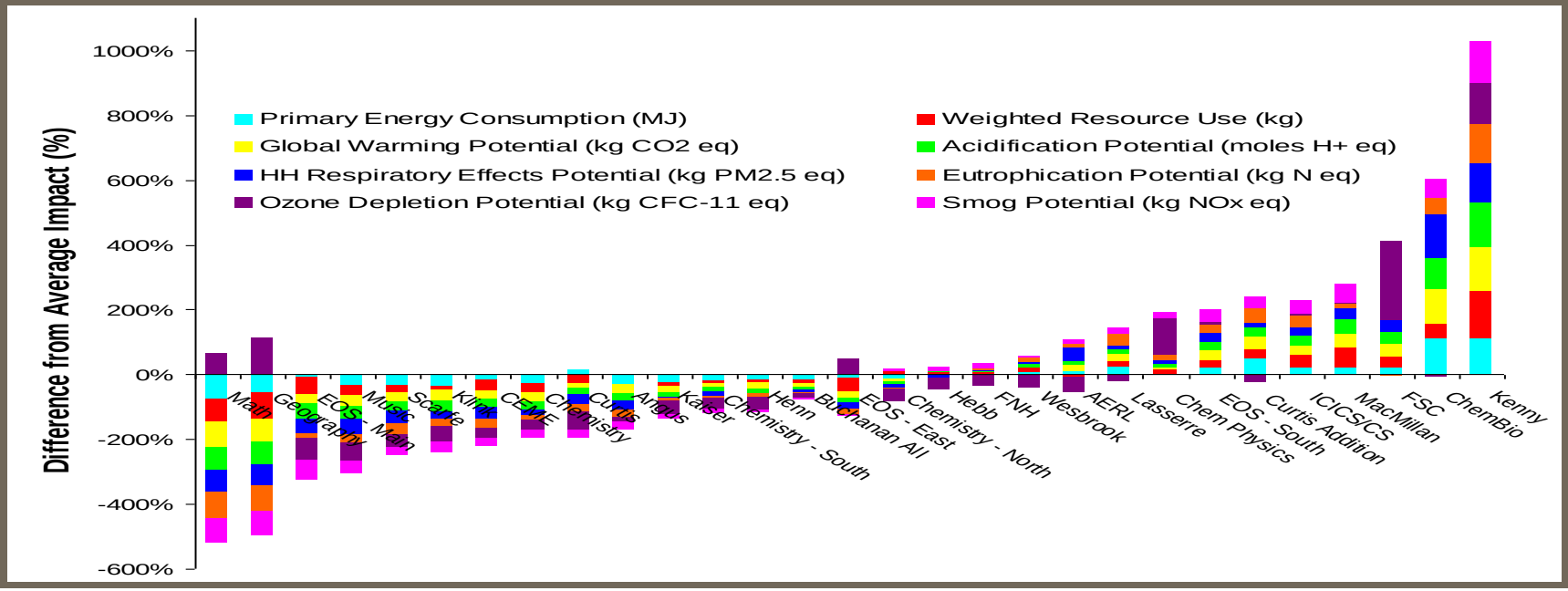


SENSITIVITY ANALYSIS
- Functional Areas -



OUTCOMES

- First ever life cycle assessment of Olympic Venues
  - To be included in Olympic Games Impact (OGI) Study…
- Addition of Thunderbird to the UBC LCA Database
  - Richmond Oval the beginning of extension into GVRD



GLOBAL APPLICATIONS: LONDON 2012

How do we compare?

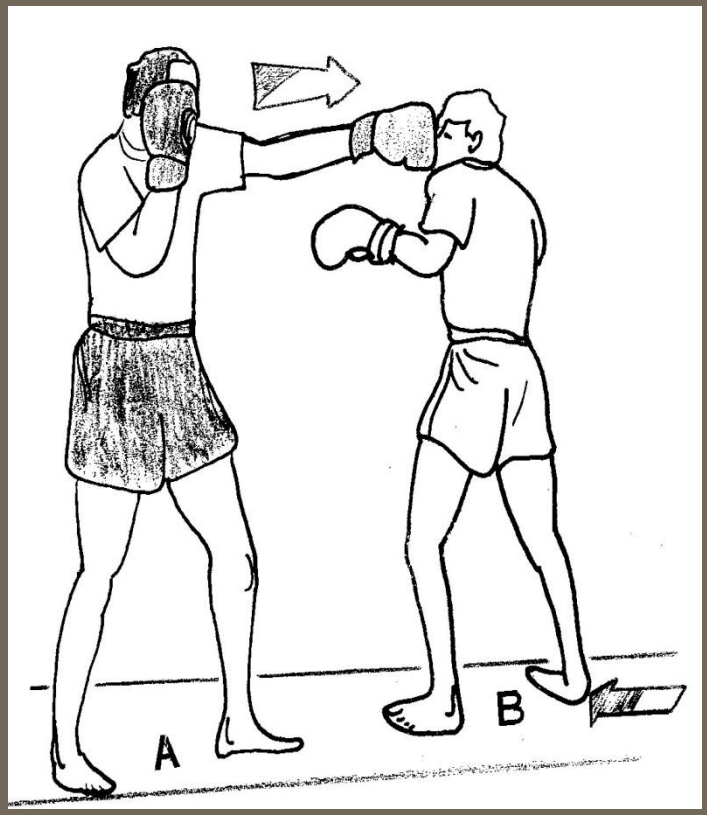
LONDON 2012

Entire Scope of Carbon Study

- Pre-games (venues, structures etc.)
- Games (spectators, operations…)
- Legacy (use after Olympics)

Identified 4 venue `biggest hitters`:

- Olympic Park Works = 48%
- Olympic Village = 23%
- Media Centre = 8%
- **Stadium/Aquatics Centre = 7%**



LONDON 2012

These buildings do not serve the same function, **however…**

RICHMOND OVAL

Seating: 8000

CO2eq: 23 kilo-tonnes

Tonnes/seat: 2.875

LONDON 2012 STADIUM

Seating:80,000

CO2eq: 129 kilo-tonnes

Tonnes/seat: 1.6125

Given that 55,000 seats in the London Stadium are temporary (and lighter structure), and the heavy earthworks required in Richmond.

Conclusions

CONCLUSIONS

LCA is a symptom of the change in the way we design products.

- Our reports are publicly available at the UBC SEEDS Library!

http://www.sustain.ubc.ca/seeds-library

CONCLUSIONS

LCA data shows us the link between decisions, products, processes and the environment.

CONCLUSIONS

“You can’t manage what you can’t measure”

CONCLUSIONS

“Call yourself green? Prove it.”

RECOMMENDATIONS

- LCA is ideally applied during the design process
  - Cost Effective
  - Change the way we make building design decisions
- An LCA is only as good as the methods used and databases available
  - Still plenty of chances for uncertainty to accumulate
  - Improve the methodology
  - Improve the databases
- Provide the tools for specialists to contribute
- Create online tool to more easily share reports and results

GLOBAL APPLICATIONS

Globally, LCA is currently being integrated at all scales of sustainable development guidelines.

The most recent developments include:

- LEED for New Construction 2009: Innovation & Design Credit 1
- LEED 2012 Pilot
- ASHRAE 189.1
- International Green Construction Code (IgCC)
- ISO 21931-1: Sustainability in Building Construction

THANK YOU!

CIVL 498C 2008/09

CIVL 498C 2009/10

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UBC Sustainability Office, UBC Records Department

AthenaInstitute

OnCenter SOFTWARE

THANK YOU!

- Introduction
  - What is LCA?
  - How can it help?
  - Goal and Scope
- Tools and methodology
  - Software
- Results
  - Environmental impact potential
  - Sensitivity analysis
  - Uncertainties
- Conclusion
  - London 2012
  - Recommendations
  - Where do we go from here?

Where do you see LCA in the future?

Suggestions?